

To sleep, perchance to dream

Jonathan Winson

Emeritus Professor, Rockefeller University, New York, New York 10021, USA

"While the neurophysiological and neurochemical bases of dreams will ultimately be uncovered, a full understanding requires an explanation of dream content that makes sense in both psychological and neurobiological terms."

Payne and Nadel 2004

First, Ken Paller (Paller and Voss 2004) is to be congratulated for bringing together a prime and comprehensive group of researchers for this special section of *Learning & Memory* that is devoted to sleep and memory. I find all of the contributions to be excellent, but I have selected for comment those that I believe speak to the longer range goals of sleep and memory research.

This section offers several important contributions to the understanding of the intimate relationship between sleep and learning. Gais and Born (2004) discuss the beneficial influences of slow-wave sleep on the formation of declarative memory. We also have a paper on the role of sleep in enhancing the learning of procedural motor skills (Kuriyama et al. 2004). Starting with Karni et al. (1994), multiple studies have shown that procedural memories are consolidated during sleep (for review, see Gais and Born 2004). In due course we can expect to understand how memories (e.g., procedural versus declarative) are processed in the various stages of sleep as the night progresses.

Carlyle Smith (Smith et al. 2004) continues his excellent work. Following training on the Tower of Hanoi or mirror tracing tasks, he reports that the number of rapid eye movements during REM sleep increases although the time spent in REM sleep does not change. Rosalind Cartwright (2004) has long noted that eye movement density increases as dreams become more emotional.

Turning to mechanisms underlying memory consolidation during sleep, in the past several years Sidarta Ribeiro has performed three groundbreaking experiments (Ribeiro and Nicolelis 2004) regarding the reverberation, storage, and propagation of memories during the different phases of sleep. (Of course, I may be biased: While I was a professor at Rockefeller University, unbeknownst to me, a student in another department was providing the first molecular corroboration of my hypothesis that REM sleep plays an essential role in the consolidation of memory.) I believe that Ribeiro and Nicolelis's (2004) description of the dynamics of information flow in the forebrain during the 48 h that follow exposure to a novel stimulus will serve as a framework for future research.

A bit more toward the psychological, Wagner et al. (2004) in *Nature* demonstrate that in a cognitive task that measures the time at which insight into a hidden rule can be determined, the rule is discovered twice as fast after sleep than after wakefulness. As an anecdotal introduction to their study, these authors cite the historical paper "What dreams may come?" (Mazzarello 2000). It seems that August Kekulé's dreams, in which he put together the structure of benzene, might not be the oddity it has long been believed but may have been the result of memory

processing during sleep. As may have been the dream of Otto Loewi that led him to the Nobel Prize-winning experiment that proved that the vagus does not directly influence the heart but does so through chemical transmission.

Several questions regarding the role of sleep and dreams in memory remain. What are the systems that interact to alter memory and produce dreams? How are they paced? What, if any, is the significance of the increase in the density of eye movements during REM sleep following learning and during emotional dreams?

We come to dreams. In the citation that begins this commentary, Payne and Nadel (2004) put it very well. We are at the very beginning. When we begin to discern the memory process by which the events of the day are recorded and intermixed with past experience, we may make sense of the myriad dreams that cannot be decoded. But some dreams are revealing. If you can decode such a dream through associations or through the frequently delightful puns your dream has produced to the events of the previous day, you may gain insight into your inner nature.

In this commentary we are now approaching consciousness. Here, dreams may make a contribution. An understanding of consciousness, particularly our sense of self, has eluded both neuroscience and philosophy. The question is how the child's brain, given the knowledge of his or her internal states and bodily control, and with the observations of animals and other humans, can convert this to the adult certainty of who we are. Foulkes's work which traces with age the shift in dreams from bodily related static themes to dynamic imagery involving the self character (Foulkes 1999) may provide a window.

References

- Cartwright, R.D. 2004. The role of sleep in changing our minds: A psychologist's discussion of papers on memory reactivation and consolidation in sleep. *Learn. Mem.* (this issue).
- Foulkes, D. 1999. *Children's dreaming and the development of consciousness*. Harvard University Press, Cambridge, MA.
- Gais, S. and Born, J. 2004. Declarative memory consolidation: Mechanisms acting during human sleep. *Learn. Mem.* (this issue).
- Karni, A., Tanne, D., Rubenstein, B.S., Askenasy, J.J., and Sagi, D. 1994. *Science* **265**: 679–682.
- Kuriyama, K., Stickgold, R., and Walker, M.P. 2004. Sleep-dependent learning and motor-skill complexity. *Learn. Mem.* (this issue).
- Mazzarello, P. 2000. What dreams may come? *Nature* **408**: 523.
- Paller, K.A. and Voss, J.L. 2004. Memory reactivation and consolidation during sleep. *Learn. Mem.* (this issue).
- Payne, J.D. and Nadel, L. 2004. Sleep, dreams, and memory consolidation: The role of the stress hormone cortisol. *Learn. Mem.* (this issue).
- Ribeiro, S. and Nicolelis, M.A.L. 2004. Reverberation, storage, and postsynaptic propagation of memories during sleep. *Learn. Mem.* (this issue).
- Smith, C.T., Nixon, M.R., and Nader, R.S. 2004. Posttraining increases in REM sleep intensity implicate REM sleep in memory processing and provide a biological marker of learning potential. *Learn. Mem.* (this issue).
- Wagner, U., Gais, S., Halder, H., Verleger, R., and Born, J. 2004. Sleep inspires insight. *Nature* **427**: 304–305.

Article and publication are at <http://www.learnmem.org/cgi/doi/10.1101/lm.86804>.